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PORTO RICO AGRICULTURAL EXPERIMENT STATION,
D. W. MAY, Agronomist in Charge,
Mayaguez, P. R.

Under the supervision of the STATES RELATIONS SERVICE,
Office of Experiment Stations, U. S. Department of Agriculture.

REPORT OF THE PORTO RICO AGRICULTURAL EXPERIMENT STATION.

1917.

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1918.

PORTO RICO AGRICULTURAL EXPERIMENT STATION.

[Under the supervision of A. C. TRUE, Director of the States Relations Service, United States Department of Agriculture.]

E. W. ALLEN, *Chief of Office of Experiment Stations.*
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LETTER OF TRANSMITTAL.

PORTO RICO AGRICULTURAL EXPERIMENT STATION,
Mayaguez, P. R., December 31, 1917.

SIR: I have the honor to transmit herewith and to recommend for publication a report of the Porto Rico Agricultural Experiment Station, 1917.

Respectfully,

D. W. MAY,
Agronomist in Charge.

Dr. A. C. TRUE,
Director States Relations Service,
U. S. Department of Agriculture, Washington, D. C.

Publication recommended.
A. C. TRUE, *Director.*
Publication authorized.
D. F. HOUSTON,
Secretary of Agriculture.

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[1] Transferred to U. S. Department of Agriculture, Bureau of Plant Industry, Apr. 17, 1918.

[2] Appointed Mar. 1, 1918, to succeed R. H. Van Zwaluwenburg, transferred to U. S. Department of Agriculture, Bureau of Entomology.

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By D. W. May.

INTRODUCTION.

The experiment station in Porto Rico, established shortly after the transfer of the island to the United States, is maintained by the Federal Government but has been equipped with lands and buildings by the insular government. Its work has been varied in character. While it has sought to improve the old industries, such as the production of sugar cane, coffee, and tobacco, it has also endeavored to diversify the agriculture by introducing and promoting in every way possible the production of new and promising crops of other tropical countries. Movements have been started under the American protectorate for the establishment of experiment stations in Santo Domingo and Haiti, a former member of the staff of the Porto Rico Station having gone to Santo Domingo to inaugurate the work.

LINES OF WORK.

The Porto Rico Station has given special attention to the study of soils, their types, physical characteristics, and fertilizer requirements. This work, which has been reported upon from time to time, is based on laboratory and plat experiments at the station and cooperative field trials in various sections of the island. Porto Rican soils have been found deficient in the three elements of fertility usually lacking, nitrogen, phosphorus, and potash, especially the first. The fertilizer bill of the island has grown from practically nothing at the time of the American occupation to $2,000,000 annually. While this expenditure has shown large returns on the investment, the station has sought to reduce it by finding local sources of the fertilizing elements.

The importance of growing legumes as cover crops in all systems of rotation is being especially impressed on Porto Rican planters. With a continuous growing season and a large number of leguminous plants, native and introduced, as the cowpea maturing in 70 days, the velvet bean in 8 months, and leguminous trees like the agati in 2 years and others in 10 to 50 years, there should be no idle land in Porto Rico and no break in crop following crop throughout the year. In many cases one crop can be planted before another is removed, and sometimes two, as corn and beans, can be planted together to

their mutual advantage, the corn supporting the beans and in return obtaining some of the nitrogen which the beans secure from the air. Further study of the planting of legumes and foresight in intercropping and diversification will result in time in all the necessary nitrogen being locally secured, thus eliminating cash expenditure for the most expensive fertilizing element while improving the physical condition of the soils and adding crops that will in time bring large returns.

During the year the work of surveying and listing the bat guanos in the caves of the island was completed, and studies were made of their value and the availability of their phosphates. This investigation has resulted in a greatly increased use of the deposits. It is hoped at a future date to take up work with the phosphate deposits in Mona Island, which lies in the channel 40 miles west of Porto Rico and belongs to her. This work, as well as that of studying methods for obtaining potash from the mother liquor from the salt works at Salinas, has had to be temporarily postponed.

FRUIT.

The fruit industry has shown commendable progress during the year, the exports running over $3,000,000. Much fruit, especially oranges and grapefruit, goes to waste on the island, due in great part with wild oranges to inaccessibility of ports of shipment and with grapefruit to imperfections and oversize.

Efforts are under way to try out on a commercial scale certain methods developed by the Bureau of Chemistry, United States Department of Agriculture, for bottling and shipping the juice of oranges and grapefruit. The custom of serving these juices in the glass is increasing at soda fountains, in hotels, and on dining cars, and laboratory tests indicate that the demand can be successfully met with bottled juices. Not only will fruits discarded for off-size or blemish of the skin be saved, but freight rates will be lowered, loss by decay in transit will be prevented, and a higher average market for the whole fruit will result, as the low-grade stuff will be bottled at the packing houses and not put on the market to depress the general quality and price of the crated goods.

The principal diseases which citrus growers have to combat are scale and scab. Methods for keeping scale in check are pretty well known and generally followed. Scab is a more serious problem, as its cause is somewhat obscure and methods of control have not as yet been definitely determined. During the year Dr. L. R. Hesler, of Cornell University, spent three months on the island studying this trouble, but a pathologist should be secured to devote his entire time to the problem and for this purpose additional appropriation is desired.

FOOD CROPS.

Besides the big staple crops, sugar, coffee, tobacco, and fruit, the station has given especial attention to the minor food crops. The uncertainty of securing imported supplies caused by shipping conditions after the United States entered the war made it necessary to pay particular attention to food production in Porto Rico, to provide material not only for exchange with other countries but for sustaining the population in case the island were cut off from the outside world. Special attention was given to the growing of beans, corn, and rice; but statistics of all the minor food crops were gathered, the first work of the kind in the history of the island.

In 1916 Porto Rico imported more than $800,000 worth of beans, which form a large part of the food of the population. During the present year, not only has the island grown enough beans to supply its own needs, but it has had a surplus to export.

The crop of corn is the largest yet produced in Porto Rico, the increased production having been accompanied by improvement in quality brought about by seed selection and better cultivation. The active propaganda carried on to secure increased production has included advice as to the milling of corn for use as a staple article of diet. This grain is not generally consumed as food at present, and efforts are being made to have it enter more largely into the dietary of the people to take the place of a part of the large amounts of imported wheat flour.

There has been an increased production of rice, and one planter growing it is employing machinery for seeding, flooding, harvesting, and thrashing. C. E. Chambliss, of the Office of Cereal Investigations of the Bureau of Plant Industry, from a survey of rice growing in Porto Rico made during the past summer, estimates that the island can produce at least one-half of the $5,000,000 worth of rice now imported annually. As a result of Mr. Chambliss's findings, cooperative work is under way between the Office of Cereal Investigations, the Porto Rico Experiment Station, and planters in different sections who make field trials in growing rice. Several tons of the best seed rice has been shipped and the latest rice machines purchased, and representative planters have agreed to put in several acres of the crop in their respective localities to give the industry a thorough try out. Every condition seems favorable to securing increased production of this crop and permanent utilization of thousands of acres of land now idle and unproductive.

COOPERATIVE AND DEMONSTRATION WORK.

With the increased resources of the station it has become possible to extend the work to other parts of the island, and cooperative and demonstration work has been undertaken in many localities.

Through the cooperation of the insular food commission, an active campaign was organized in May, 1917, to stimulate food production in Porto Rico, so as to render the island less dependent on the mainland for maintenance. (Pls. I and IV, fig. 2.) For convenience, the field of endeavor has been divided along two lines, H. C. Henricksen having direction of the work with fruits and other crops on the northern side of Porto Rico and W. A. Mace the crop investigation and demonstration on the southern and western part of the island.

VIRGIN ISLANDS OF THE UNITED STATES.

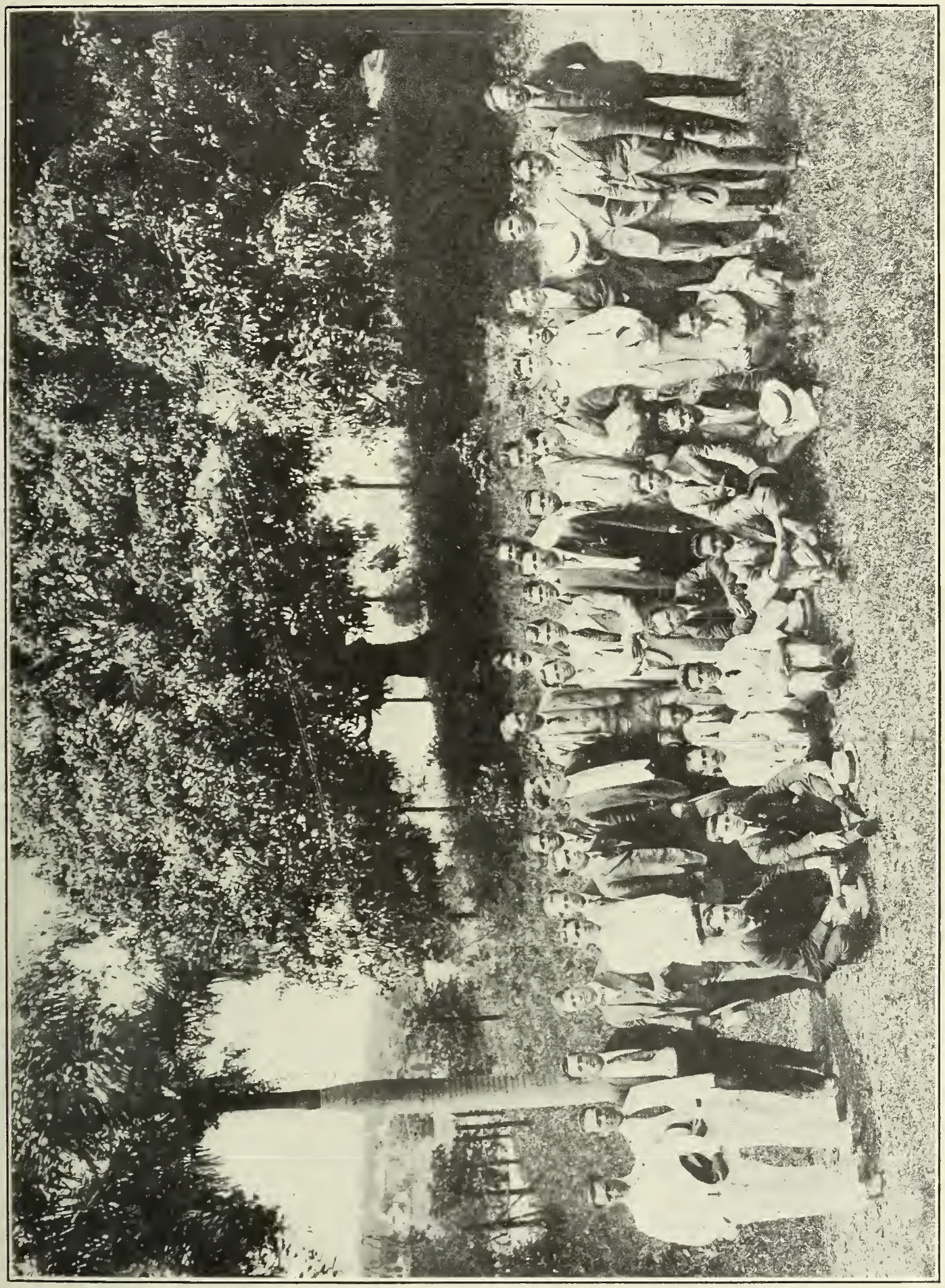
Shortly after the transfer of the Danish West Indies to the United States, Gov. James H. Oliver requested the Department of Agriculture to have a survey made of the agricultural possibilities of the islands and to outline the best methods for their development. The writer was detailed for the work. He visited St. Thomas, St. Croix, and St. John, traveling over them and conferring with planters engaged in the various lines of production.

Of the three principal islands of the group, St. Croix is the largest, being 21 miles long and an average of about 6 miles wide, as well as the best from an agricultural point of view, having a fertile soil easily worked. The leading crop is sugar cane, with sea island cotton second. The island is deficient in moisture, the average rainfall for 60 years being slightly under 50 inches, an amount insufficient for the maximum production of sugar cane. Fertilizers have not been generally successful, owing, it is claimed, to the fact that there is not enough moisture present in the soil for their ready solution and use by crops.

St. Thomas, second in size, is about 14 miles in length and contains the excellent harbor that lends especial value to the group. It is hilly and not well watered, but grows excellent grasses. Some trucking is done in the valleys, the produce being sold locally and for supplying ships.

St. John, a mountainous island about 12 miles long, is third in size and produces principally cattle, oil of bay, and excellent guinea grass, the sole food of the cattle. Once the seat of a flourishing agriculture, as shown by the remains of old mansions and cane mills, St. John lost its prosperity with the freeing of the slaves, and the island is now occupied by about 1,000 people, for the most part making a precarious living from fishing and trading with the port of St. Thomas.

An experiment station was established by the Danish Government in St. Croix on 215 acres of fertile land with fair equipment and buildings, but the income now secured from local sources is not sufficient for proper maintenance. No greater good could be done the Virgin Islands than to maintain an efficient experiment station.



EMERGENCY FOOD PRODUCTION STAFF.

In St. Croix an examination should first be undertaken of the character and amount of the underground waters with the view of utilizing them for irrigation. With enough irrigation water added to the rainfall to produce maximum crops, the production could be increased to an enormous extent. Following the use of more water, fertilizer experiments should be undertaken to determine the needs of the various crops and the types of soil. On St. Thomas, work in producing vegetables and minor crops for local consumption and for ships' stores should be inaugurated, with especial attention given to sanitary milk production. Certain new crops should be tried out on St. John and considerable demonstration work done among the people with the object of restoring the agriculture of the island and the prosperity of its people.

REPORT OF THE CHEMIST AND ASSISTANT CHEMIST.

By P. L. Gile and J. O. Carrero.

Work on the efficiencies of various phosphates in Porto Rican soils received most attention during the past year. It was possible, however, to continue an investigation of chlorosis of sugar cane that has been in progress for some time and to commence two other studies of less scope.

The work done on the chlorosis of sugar cane is given below in detail. In its present form it was completed sometime ago, but reporting the results was delayed pending the investigation of an apparently contradictory result secured in the ash analyses.

ANALYTICAL WORK.

Some 300 samples were analyzed the past year, the greater number being plants in which one or more mineral constituents were determined. A considerable number of miscellaneous materials sent to the laboratory for identification were tested qualitatively. These included chiefly samples of guanos, pyrites, manganese, and kaolin.

PHOSPHATES IN PORTO RICAN SOILS.

Thus far results have been secured from three soils on the relative efficiencies of different phosphates, on the degree that liming affects efficiencies, and on the rate at which phosphoric acid becomes unavailable by remaining in the soil. Work with four other soils is in progress and others will be studied as rapidly as facilities permit. In the completed tests, 200 or more pots were used with each different soil. It is hoped to test all the main soil types on this scale and some less important types less extensively.

LIME-INDUCED CHLOROSIS.

The past year, results of direct experiments and related studies showing the cause and nature of lime-induced chlorosis were being prepared for publication, but it was found necessary to conduct another experiment. The work will doubtless be finished the coming year.

ABSORPTION OF NUTRIENTS AS AFFECTED BY DISTRIBUTION OF NUTRIENTS TO THE ROOTS.

This work is an extension of that published last year, which showed how the absorption of a nutrient was affected by the number of roots supplied with the nutrient. The first study considered the absorption of various elements when part of the roots were maintained in a complete nutrient solution and part in a nutrient solution lacking one element. In the present work the absorptions of nitrogen, phosphoric acid, and potash are measured when the roots of the plant are divided between two incomplete solutions and when the roots are divided between three incomplete solutions. This study should be completed the coming year. It throws some light on factors governing the absorption of mineral nutrients.

RELATIVE EFFICIENCIES OF SULPHATE OF AMMONIA AND NITRATE OF SODA FOR RICE.

A vegetation experiment in pots was conducted to test the relative efficiencies of sulphate of ammonia and nitrate of soda for rice under several conditions. As the plants seemed to absorb or utilize the two forms of nitrogen at different times, it was necessary to conduct an experiment to observe the influence of time of application on the amount of nitrogen recoverable in the crop. These two tests have just been completed and will be published shortly unless it seems advisable to prosecute the work further.

CHLOROSIS OF SUGAR CANE.

In the southern part of the island from Yauco to Salinas there are numerous restricted areas where sugar cane suffers more or less from chlorosis. The size of markedly chlorotic areas varies from a few stools to an acre. There are, however, some fields of many acres near Santa Isabel which are irregularly affected, a large portion of the cane being more or less chlorotic at times.

In most pronounced cases of this chlorosis the leaves are of normal size but creamy white in color. In less advanced stages the midrib only may be green, or the midrib and veins green with the parenchymous tissue colorless, giving the leaf a striated appearance. Cane so affected often dies but more frequently recovers most of its green color only to lose it again later. The chlorosis may appear at any

stage of growth from two months after planting up to the time of arrowing. Ratoons seem to suffer more than plant cane, and B 1753 is a little more resistant than Cristalina, Otaheite, or B 208. This same chlorosis has been observed in Hawaii and some islands of the West Indies, but never over any great area.

In a few cases the chlorosis appears in the same spot year after year and the cane is more or less affected throughout the period of growth. Many of these areas are no longer planted. Sometimes certain spots in a field are markedly chlorotic one year and very little affected another year. In nearly all cases under observation the degree to which the cane was affected varied greatly at different times during the growth of the cane. The variation in degree of chlorosis did not correspond to any particular age of the cane but did seem to show some correspondence with activity of growth and rainfall.

The marked similarity of this chlorosis of sugar cane to that previously observed in pineapples[1] indicated that cane chlorosis was probably also associated with an excessive amount of carbonate of lime in the soil. A soil survey was accordingly made of the principal areas where cane was affected.

SURVEY OF SOILS PRODUCING CHLOROTIC CANE.

Samples of the first and second foot of soil were taken from areas where cane was markedly chlorotic and from the nearest areas where cane was perfectly green at that time. These comparative samples were in most cases only a few yards apart. While there was a very great difference in color and size between the green and chlorotic cane at the time the samples were taken, it should be borne in mind that in some cases this difference doubtless diminished later, the green cane becoming chlorotic for a time or the chlorotic cane becoming greener. On soil No. 452, the cane was green and well grown, although in previous years there had been some chlorotic patches in this field.

Samples marked "always green" in the table given below were from fields near the chlorotic cane which, in the long experience of the planters, were known never to have produced chlorotic cane. Only three of these samples were taken, as in most cases it could not be said that the cane on adjacent areas never showed slight chlorosis in small patches. No attempt was made to analyze soils from all fields which produce green cane.

Besides the analysis of samples by the usual method of acid digestion, determinations were made of the water-soluble constituents. The analytical results are given in the table following.

[1] Porto Rico Sta. Bul. 11 (1911).

Analyses of soils producing green and chlorotic cane.

Laboratory number.	Locality.	Condition of cane.[1]	Acid analysis.											Water analysis.						
			Insoluble matter.	Volatile matter.	Alumina (Al_2O_3).	Ferric oxid (Fe_2O_3).	Lime (CaO).	Magnesia (MgO).	Potash (K_2O).	Phosphorus pentoxid (P_2O_5).	Carbon dioxid (CO_2).	Carbonate of lime ($CaCO_3$).	Nitrogen (N).	Bicarbonate (HCO_3).	Carbonate (CO_3).	Chlorid (Cl_2).	Sulphate (SO_3).	Lime (CaO).	Magnesia (MgO).	Total salts as sulphates.
	Ponce, Hacienda Mercedita, Field No. 3, Isabela poniente:		*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
389	Soil	C	31.44	30.11	4.21	5.70	28.12	0.33	0.48	0.21	.....	42.25	0.16	0.0721	0	0.0057	0.0073	0.0249	0.0045	0.1190
390	Subsoil	.....	24.46	32.88	4.06	3.34	34.58	.20	.34	.07	26.52	60.28	.16	.0615	0	.0062	.0075	.0196	.0041	.0997
391	Soil	G	33.89	29.14	4.34	4.10	26.11	.22	.57	.16	19.72	44.82	.22	.0655	0	.0027	.0065	.0198	.0042	.1122
392	Subsoil	.....	32.56	28.76	5.98	4.05	27.21	Trace.	.63	.05	20.20	45.91	.01	.0765	0	.0054	.0087	.0207	.0054	.1267
400	Soil	G	28.39	31.48	5.08	3.75	29.23	Trace.	.16	.14	21.69	49.19	.20	.0721	0	.0044	.0029	.0249	.0034	.1150
401	Subsoil	.....	19.53	35.52	3.85	2.56	36.79	.91	.25	.13	27.91	63.43	.14	.0713	0	.0052	.0058	.0253	.0022	.1114
	Ponce, Hacienda Mercedita, Field No. 1, Logroño:																			
420	Soil	C	22.39	34.51	4.67	1.89	35.14	.63	.28	.26	25.57	58.11	.29	.0638	0	.0045	.....	.0509	.....	.0827
421	Subsoil	.....	12.01	39.19	2.40	1.70	43.91	.84	.06	.14	35.19	79.98	.12	.0331	0	.0062	.....	.0452	.....	.0801
422	Soil	G	23.73	34.53	4.59	3.40	32.19	1.32	.05	.19	26.81	76.70	.33	.0683	0	.0045	.....	.0529	.....	.1021
423	Subsoil	.....	21.45	34.40	4.42	3.82	34.21	1.56	.04	.10	24.85	56.49	.23	.0637	0	.0072	.....	.0484	.....	.0935
	Santa Isabel, Hacienda Florida:																			
386	Soil	C	57.47	15.66	8.61	7.82	8.98	1.26	.46	.19	5.15	11.70	.21	.0780	0	.0068	.....	.0238	.0021	.1329
387	Subsoil	.....	53.81	.....	8.91	7.93	12.84	1.08	.29	.13	9.63	20.91	.06	.0629	.0017	.0061	.....	.0145	.0041	.1168
388	Soil	G	63.50	12.02	10.04	8.55	5.53	.37	.40	.12	2.30	5.22	.16	.0748	0	.0048	.....	.0210	.0080	.1074
402	Subsoil	.....	56.45	13.40	11.33	5.02	9.47	3.03	.05	.25	5.84	13.28	.04	.0603	0	.0044	.0018	.0117	.0072	.0900
403	Soil	C	57.67	15.08	6.90	6.62	9.80	3.30	.35	.13	5.83	13.23	.20	.0768	0	.0045	.0016	.0260	.0052	.1348
404	Subsoil	.....	53.73	15.97	9.05	4.35	13.08	3.47	.20	.21	9.28	21.10	.07	.0623	0	.0062	.0051	.0170	.0084	.1158
405	Soil	G	65.56	11.07	9.48	7.97	2.33	1.94	.50	.20	.13	.29	.16	.0618	0	.0053	.0153	.0212	.0049	.1086
406	Subsoil	.....	57.50	13.04	8.51	7.66	9.33	2.37	.30	.15	5.46	12.50	.06	.0582	0	.0044	.0195	.0197	.0042	.0979
407	Soil	AG	66.80	8.69	9.82	8.40	3.18	2.44	.42	.05	.07	.16	.13	.0742	0	.0059	.0133	.0235	.0046	.1123
408	Subsoil	.....	64.14	10.42	9.37	7.88	4.52	2.37	.60	.30	1.38	3.13	.08	.0495	0	.0044	.0146	.0189	.0045	.0809
	Santa Isabel, Central Cortada, Field No. 11, Mejias:																			
409	Soil	C	48.94	22.28	7.15	5.63	10.56	5.03	.34	.46	6.87	16.79	.32	.0814	0	.0091	.0127	.0226	.0078	.1527
410	Subsoil	.....	28.23	30.50	9.15	3.65	27.58	1.89	.49	.07	12.54	28.52	.09	.1262	0	.0171	.0297	.0116	.0060	.1898

	Santa Isabel, Central Cortada, near mill:																			
411	Soil	AG	55.74	12.84	14.54	9.89	3.08	3.62	.23	.06	Trace.	Trace.	.22	.0443	0	.0064	.....	.0242	.....	.0624
412	Subsoil	.....	60.67	11.83	11.94	9.79	2.56	2.46	.31	.13	Trace.	Trace.	.004	.0481	0	.0053	.....	.0298	.....	.0730
	Santa Isabel, Central Cortada, Field No. 0, Carretera:																			
470	Soil	C	42.98	23.99	13.19	5.52	11.07	2.53	.25	.22	10.60	24.09	.11	.0655	0	.0065	.0135	.0305	.0131	.1719
471	Subsoil	.....	33.32	25.95	11.30	5.64	23.70	1.29	.11	.06	19.23	43.70	.03	.0520	0	.0050	.0078	.0145	.0086	.0852
	Ponce, Hacienda Amelia, Field No. 1052:																			
424	Soil	C	41.13	24.10	2.70	9.11	19.41	2.65	.30	.36	11.35	25.77	.28	.0778	0	.0056	.0037	.0323	.0035	.1304
425	Subsoil	.....	36.76	25.06	5.23	5.81	23.77	2.85	.10	.19	19.53	44.38	.15	.0560	0	.0055	.0038	.0265	.0039	.1172
	Ponce, Hacienda Amelia, Field Guirivaldi:																			
426	Soil	G	60.54	14.10	9.22	8.24	3.68	2.14	.44	.18	Trace.	Trace.	.32	.0678	0	.0056	.0026	.0236	.0024	.1107
427	Subsoil	.....	63.39	12.68	9.32	8.25	4.56	2.32	.24	.15	2.95	6.70	.16	.0536	0	.0042	.0019	.0213	.0028	.1032
	Yauco, Hacienda Montserrate, Field No. 48:																			
428	Soil	C	47.77	17.74	9.83	8.69	11.33	3.54	.59	.38	7.03	15.98	.11	.0631	0	.0014	.0048	.0224	.0041	.0959
429	Subsoil	.....	42.80	19.80	12.83	5.55	16.77	1.92	.24	.27	13.33	30.29	.05	.0597	0	.0051	.0099	.0202	.0054	.0876
430	Soil	G	46.82	12.36	12.94	9.57	3.89	3.86	.41	.15	1.34	3.05	.06	.0674	0	.0056	.0109	.0264	.0031	.0949
431	Subsoil	.....	50.01	15.27	15.89	6.44	11.05	1.57	.34	.36	5.85	12.83	.05	.0458	0	.0051	.0033	.0172	.0038	.0909
	Yauco, Hacienda Santa Rita, Field No. 10:																			
432	Soil	C	46.74	24.60	10.28	5.13	10.02	1.95	.47	.23	6.84	15.54	.19	.0697	0	.0026	.0092	.0275	.0062	.1281
433	Subsoil	.....	38.22	23.57	9.56	2.98	25.05	.41	.22	.17	17.15	39.07	.09	.0641	0	.0056	.0138	.0285	.0063	.1202
434	Soil	AG	59.13	13.18	8.23	11.47	2.00	5.13	.46	.15	Trace.	Trace.	.20	.0799	0	.0076	.0117	.0232	.0120	.1412
435	Subsoil	.....	59.17	12.51	8.20	11.67	1.90	5.64	.36	.13	Trace.	Trace.	.11	.0687	0	.0057	.0108	.0162	.0106	.1242
	Yauco, Hacienda Florida:																			
452	Soil	G	24.81	32.27	8.54	4.34	28.78	.69	.42	.19	21.99	49.98	.09	.0789	0	.0072	.0143	.0358	.0051	.1326
453	Subsoil	.....	9.48	39.16	4.07	1.06	45.53	.59	.33	.10	35.70	81.13	.03	.0569	0	.0097	.0106	.0292	.0057	.0835

[1]C, chlorotic; G, green; AG, always green, i. e., samples from fields which have never produced chlorotic cane.

There was no correspondence between the chlorosis of the cane and the percentage of any of the constituents determined in the acid or water extracts of the soils, although all soils producing chlorosis were strongly calcareous. While chlorotic cane was found only on markedly calcareous soils, all calcareous soils did not produce chlorotic cane. Cane, which for the time at least was green and vigorous, was found on a soil containing as much as 76.70 per cent[1] of carbonate of lime, and chlorotic cane was found on a soil containing as little as 13.23 per cent.

The three samples from fields where cane had never shown chlorosis contained only a trace of carbonate of lime. All soils in the southern part of the island where cane had never shown chlorosis were not examined, but doubtless many of them contain fairly high percentages of lime as carbonate. No consistent differences in regard to drainage or other physical features of the soils producing green and chlorotic cane were observable in the field.

From the preceding analyses it appears that this type of chlorosis of sugar cane occurs only on excessively calcareous soils but not on all such soils. This conclusion is justified by several years' subsequent observation.

EXAMINATION OF GREEN AND CHLOROTIC CANES FOR FUNGI.

The chlorotic and green canes growing where the samples were taken were examined in the field by J. R. Johnston[2] for evidences of disease. Pathogenic fungi were found on some but not all chlorotic cane, as well as on some green cane. On the whole, chlorotic canes did not seem to be attacked by fungi to any greater extent than were green canes.

ASH ANALYSES OF GREEN AND CHLOROTIC LEAVES.

As lime-induced chlorosis of pineapples was found to be associated in part at least with a lack of iron in the plant, analyses were made of comparative samples of green and chlorotic cane leaves for iron, lime, etc. The results are given in the table following.

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[1] Green cane in this field yielded as high as 50 and 60 tons per acre.

[2] At that time pathologist of the Sugar Producers' Association of Porto Rico.

Ash analyses of green and chlorotic cane leaves.

Laboratory No.	Condition of leaves.	Carbon-free ash in dry substance.	Analyses of carbon-free ash.			
			Silica (SiO_2).	Lime (CaO).	Magnesia (MgO).	Iron (Fe_2O_3).
	B1753:	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
455	Green	8.70	48.10	4.07	3.20	0.68
454	Chlototic	9.17	38.01	3.85	3.34	.45
	Cristalina:					
707	Green	5.62	31.50	3.12	5.35	.153
708	Chlorotic	6.92	33.15	3.61	4.61	.124
709	Green	6.68	39.39	3.52	4.36	.160
710	Chlorotic	6.58	29.29	2.74	4.90	.130
	Otaheite:					
711	Green	5.45	40.21	4.77	3.45	.197
712	Chlorotic	7.02	37.69	3.85	3.79	.132
	Rayada and Otaheite, mixed:					
726	Green	7.87	45.61	8.64	5.50	.154
725	Slightly chlorotic	9.44	53.18	8.26	4.68	.144
724	Chlorotic	9.63	48.77	6.75	4.85	.163

Nos. 454 and 455 were the youngest fully formed leaves of B1753 cane, 8 months old, growing in soil No. 432 (table, p. 12). No. 455 was composed of green leaves from two stools previously made green by treatment with ferrous sulphate. No. 454 was from adjacent chlorotic stools.

Nos. 707 and 708 were, respectively, green and chlorotic new leaves from Cristalina cane, 9½ months old, growing within 10 feet of each other in soil No. 409 (table, p. 12). The canes had about 8 feet of stalk.

Nos. 709 and 710 were, respectively, green and chlorotic young leaves of the same age and kind of cane as Nos. 707 and 708 and were growing near the latter. They had only made about one-half the growth of Nos. 707 and 708.

Nos. 711 and 712 were, respectively, green and chlorotic new leaves from Otaheite canes, 13 months old, growing near each other in the field from which soils Nos. 420 and 422 were taken. The canes had about 10 feet of stalk.

Nos. 724, 725, and 726 were, respectively, chlorotic, slightly chlorotic, and green leaves of mixed Rayada and Otaheite cane, 3 months old, the chlorotic cane growing near where soil No. 432 was taken and the green cane near soil No. 434. Each sample was composed of the third youngest leaf from about 50 stools. Canes from which No. 726 was taken were much larger than those from which Nos. 724 and 725 were taken.

Where the comparative samples of green and chlorotic leaves were taken from canes of equal size growing in approximately the same soil (samples Nos. 455 to 712), the chlorotic sample had in each case a distinctly lower percentage of iron in the ash than the green sample. The percentage of the other constituents determined did not show any regular correspondence with the color of the cane. In the

comparison between samples Nos. 724, 725, and 726, which were from canes of markedly different size growing on different soils, the chlorotic cane had very slightly more iron in the ash than the green cane.

If the last comparison were as valid as the first four comparisons the conclusion would be that the chlorosis is not connected with a lack of iron in the plant. In the light of subsequent work it appears probable that the comparison between samples Nos. 724–726 was not so fair as that afforded by the other samples. On this assumption the conclusion from the ash analyses is that the chlorosis is caused or accompanied by a lack of iron in the plant.

Considerable work was done with other plants because of apparent exceptions similar to that afforded by samples Nos. 724–726. As the details of this work have been published elsewhere they will not be fully discussed here. It is sufficient to note that in certain cases of extreme difference in growth it was found that plants lacking iron contained as high percentages of iron as plants well supplied with iron,[1] and that in other cases, where the development of the plants varied considerably, their percentages of iron did not reflect their need for iron at all stages of growth.[2] These exceptions are probably to be explained by the variation in the iron content of the whole plants at various stages of growth,[3] the marked difference in iron content of old and young leaves, and the probable immobility of iron in the plant after it has once been transported to the leaves.[4]

In view of the above facts it is believed that the comparisons afforded by samples Nos. 455–712 were fair, as they were made up of leaves of the same development from plants of equal growth,[5] and that possibly the comparison of samples Nos. 724–726 was not fair, as the leaves may have been of different age, the canes being of markedly different growth.

TREATMENT OF CHLOROTIC CANE WITH IRON AND STABLE MANURE.

As chlorotic pineapples were made green by brushing the leaves with ferrous sulphate, the same treatment was tried on sugar cane. In Haciendas Amelia and Santa Rita, two stools of cane with creamy white leaves in the midst of strongly affected areas were brushed three or four times with a 5 per cent solution of ferrous sulphate.

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[1] Gile, P. L., and Carrero, J. O. Assimilation of iron by rice from certain nutrient solutions. U. S. Dept. Agr., Jour. Agr. Research, 7 (1916), No. 12, pp. 523, 524.

[2] Gile, P. L., and Ageton, C. N. The effect of strongly calcareous soils on the growth and ash composition of certain plants. Porto Rico Sta. Bul. 16 (1914), pp. 30, 31.

[3] Gile, P. L., and Carrero, J. O. Ash composition of upland rice at various stages of growth. U. S. Dept. Agr., Jour. Agr. Research, 5 (1915), No. 9, p. 357.

[4] Gile, P. L., and Carrero, J. O. Immobility of iron in the plant. U. S. Dept. Agr., Jour. Agr. Research, 7 (1916), No. 2, p. 83.

[5] It was, of course, possible to obtain green and chlorotic leaves from canes of equal growth only because these canes were alternately green and chlorotic during growth.

These stools soon became green, presenting a strong contrast to the surrounding chlorotic cane. The striking result of this test confirms the preceding evidence obtained from ash analyses and shows that the chlorosis is due in part at least to a lack of iron in the plant.

Although this treatment did not seem commercially feasible with pineapples, there was a possibility of its proving so with cane, since, as shown by the soil survey, cane is more resistant to lime-induced chlorosis than are pineapples.[1]

A field experiment was started at Central Cortada in 1911 on a quite uniform piece of chlorotic cane. The plats were one-twenty-fifth acre each and each different treatment was replicated on three scattered plats. The special treatments of the plats were as follows: (1) Checks, no special treatment; (2) ferrous sulphate applied to soil at rate of 100 pounds per acre; (3) stable manure with 5 per cent its weight of ferrous sulphate applied to soil at rate of 10 tons per acre; (4) stable manure applied to soil at rate of 10 tons per acre; (5) cane sprayed three times with a 5 per cent solution of ferrous sulphate at intervals of two months.

The field was planted with Cristalina cane in September, 1911, and the special additions were worked into the soil around the stools November 29, at which time the cane was markedly chlorotic. The first spraying was given January 10, 1912. Through an oversight the plats were cut in January, 1913, before the weights could be obtained, but the appearance during growth was as follows:

January 10, 1912, no concordant differences observable between plats; March 7, 1912, canes on plats receiving treatments Nos. 3 and 5 were larger and better colored than those on the remaining plats, which were all equally poor; May 9, 1912, plats receiving treatment No. 3 were best, those receiving No. 5 next, those receiving No. 4 next, those receiving Nos. 1 and 2 equally inferior to the preceding;

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[1] Recently Johnson found in Hawaii (Hawaii Sta. Press Bul. 51 (1916)) that the chlorosis of pineapples occurring on manganese soils could be effectively overcome by spraying with ferrous sulphate. The treatment is a commercial success there, as only two to four sprayings to a crop are needed to maintain the green color and normal growth of the plants.

This discovery is not necessarily incompatible with the work at the Porto Rico Station on the lime-induced chlorosis of pineapples, rice, and sugar cane, in the course of which it appeared that so many sprayings were required to suppress the lime chlorosis as to make the treatment commercially unfeasible. It is true, however, that the work at the Porto Rico Station with rice and pineapples was on a very small scale. Possibly with more extensive trials or with variations in the method of application, the treatment might prove profitable for lime-induced chlorosis also, but such an assumption is not justifiable from the work already done.

It has been pointed out that lime-induced chlorosis is apparently due merely to a lack of iron in the plant caused by the fact that carbonate of lime depresses the availability of iron in the soil, and manganese chlorosis may be essentially the same, except that manganese rather than lime depresses the availability of the iron (Science, n. ser., 44 (1916), No. 1146, pp. 855–857). If this were so, it would not necessarily follow that the same *amount* of treatment would cure the two forms of chlorosis, since manganese and lime might depress the availability of iron to different extents.

August 15, 1912, plats receiving treatment No. 3 best, then No. 4, then No. 5, Nos. 1 and 2 both inferior; October 29, 1912, plats about the same as on August 15.

It is apparent that ferrous sulphate mixed with stable manure gave the best results, being superior to manure alone or to ferrous sulphate alone, which was no better than the check. So long as the plats receiving ferrous sulphate on the leaves could be sprayed these were among the best, but when this treatment had to be discontinued because of the size of the cane, these plats fell behind. It appears that, as in the case of pineapples, spraying with ferrous sulphate to be effective must be done frequently and continuously and is therefore not commercially feasible.

It was thought possible that dusting the leaves with powdered ferrous sulphate might prove more effective than spraying, as more iron could be applied at a time and with less labor. To test this point and to observe the effect of smaller amounts of stable manure, a second experiment was started in 1912. There were 20 plats of one-fourth acre each and four treatments, each different treatment being replicated on five scattered plats. The treatment and yield of plats are shown in the table given below. The mixtures of stable manure and ferrous sulphate, applied at the rate of 4 tons per acre, were worked into the furrow before planting. Cristalina cane was planted the middle of November, 1912, and cut January, 1914. The powdered ferrous sulphate was applied to the plants in April and June, 1913, each application being at the rate of 75 pounds per acre.

Effect of manure and ferrous sulphate on chlorotic cane.

Special treatment of plats.	Yield per acre of individual plats.					Average yield per acre.	Gain over checks per acre.
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
No treatment, checks	36.2	22.1	29.2	23.0	32.0	28.5±1.8	.....
Ferrous sulphate applied to leaves	34.5	19.8	24.3	28.0	41.8	29.7±2.6	1.4
Manure with 5 per cent ferrous sulphate	29.5	32.1	22.4	31.4	30.8	29.2±1.2	.7
Manure with 10 per cent ferrous sulphate	31.2	36.9	34.9	33.3	32.4	33.7±0.7	5.2

No marked concordant differences in the plats were noticeable during growth. Treatment with powdered ferrous sulphate not only did not appear to improve the color of the cane in the same way as spraying in the preceding experiment, but produced some injury where crystals lodged at the base of the leaf.

The yield of the replicated plats was quite variable, as was to be expected from the variations always to be seen in a field of chlorotic cane. The average yields, however, should be considered reliable, as the replicated plats were well scattered over the field. It appears

that manure with 10 per cent ferrous sulphate was the only application producing a significant increase in yield. The increase, however, was not sufficiently large to make the treatment profitable when the price of sugar is low. The results serve to confirm observations made in the preceding experiment where no quantitative data were secured, but where differences appeared much larger with larger applications of the materials.

While the preceding experiments show that the chlorosis is ameliorated to some extent by the application of stable manure containing ferrous sulphate and stable manure alone, small applications of these materials produced very slight improvement and larger applications, though more effective, by no means overcame the chlorosis completely.

DISCUSSION OF RESULTS.

The preceding study shows that lime-induced chlorosis occurs only on calcareous soils, but not on all calcareous soils, and that it is probably caused by a lack of iron in the plant. The lack of iron in the plant is doubtless caused by the fact that the carbonate of lime depresses the availability of iron in the soil. It is evident, however, that in most soils the carbonate of lime does not depress the availability of iron below the amount needed by cane, although it does depress the availability below the amount needed by pineapples.[1] On those calcareous soils where chlorosis occurred, the availability of the iron must have been less than where chlorosis did not occur, but it was not evident just what conditions served to lower the availability.[2] The amount of organic matter in calcareous soils has been found to affect somewhat the amount of available iron in calcareous soils, and work, which is in the preliminary stage at present, seems to show that another factor is of marked influence.

This work on the chlorosis of sugar cane throws some light on the general subject of lime-induced chlorosis, since the data were obtained in the study of a plant that is relatively resistant to chlorosis. The ash analyses of green and chlorotic leaves show that the chlorotic leaves contained no more lime in the ash than the green leaves, and therefore increased assimilation of lime is probably not a contributory cause of chlorosis. This point was in doubt in previous work. The preceding data point to the existence of factors affecting the extent to which carbonate of lime depresses the availability of iron in the soil.

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[1] This is shown by the fact that pineapples were found chlorotic on all calcareous soils (see Porto Rico Sta. Bul. 11 (1911)), and also by the work reported in Porto Rico Sta. Bul. 16 (1914), where pineapples and cane were grown on the same soils, the pineapples becoming chlorotic and the cane not.

[2] Evidently not alkaline salts. See table on page 12.

The method of supplying iron to the plants through the leaves was evidently effective, but was apparently not commercially feasible. The addition of organic matter, as stable manure, was beneficial, but obviously a great amount is required to produce a marked effect.

REPORT OF THE HORTICULTURIST.

By C. F. Kinman.

SWEET POTATOES.

In December, 1916, seed material of 16 varieties of sweet potatoes was received from the Bureau of Plant Industry, United States Department of Agriculture. In the spring simultaneous plantings were made from these and from plants of the same varieties received from the same source in 1911, the latter having been in cultivation here for nearly six years. Fair yields were realized from all plats. The quantity and appearance of the potatoes produced from plants of one importation did not vary to any great extent from those of the others and all were markedly inferior in texture and flavor to those sent here from the North. The few roots which reached marketable size early in the season were superior in texture to the later ones. These, however, composed only a small part of the crop. The roots produced during the summer, when the soil is usually wet and when vines are making a rank growth, grow slowly and, with the exception of a few varieties, become hard before they are full sized and when cooked are dry and of poor flavor. The roots from late fall plantings which develop during the season of light rainfall are usually of better texture than the summer crop. It is planned to make plantings of the stock on hand and of another importation from the North to continue the testing of the apparent deterioration of northern types when grown in Porto Rico.

In further tests with Porto Rican types a variety locally known as Blanca has been found to produce roots which are superior to any of the lately introduced northern varieties both in texture and flavor. The vines of the Blanca make a vigorous growth and the yield of roots from station plats has been equal to the average of that from other varieties. When cooked, this sweet potato has a good moisture content, is tender, and is decidedly richer than the lately introduced kinds and probably more so than any common type grown here excepting the one known as mamey. The latter variety, which was mentioned in last year's report, is becoming well known in many localities of the island and its cultivation is rapidly increasing. While it is reported in many localites as producng somewhat lower yields than most other varieties, its production in Mayaguez this year has been only slightly below the average of other

kinds. The vines are moderate growers, the roots smooth and medium sized, with light yellow skin and rich salmon-colored meat of first-class texture and flavor. This variety commands a considerably higher price than other kinds.

As it is the unvarying practice in Porto Rico to plant sweet potatoes by vine cuttings, the ordinarily low yields could probably be greatly increased by using plants taken from bedded roots at least once every two or three years.

COCONUTS.

In an experiment with coconut fertilization conducted for a number of years in a bearing grove, the number of nuts collected from the plats given a complete fertilizer fell off somewhat at the last harvest, as compared with the check plats, the fertilized plats not having made normal gains for several months. As the last application of fertilizer was given in June, 1916, it is possible that this falling off in yield results from the discontinuation of fertilization. It was not expected, however, that the fertilizer would cease to be effective at so early a date, as a much longer time intervened between the first application of fertilizer and the cessation of marked gains in yield of fertilized over unfertilized trees. The records of these plats will be taken for at least another year to determine the final result of the applications of fertilizers.

During the past year a survey of the coconut plantations of the island was inaugurated, and data have been collected regarding the number and size of nuts harvested in the respective groves, the soils planted to this crop, and the cultivation given, in an effort to determine the most profitable practices. As a coconut grove, if planted in suitable soil, will withstand prolonged neglect, many of the groves in Porto Rico are left entirely without care, and the annual production of this important food, as well as the grove owners' profits, are far below what might readily be obtained. Cultivation to eradicate grasses, break up sod, and stir the surface soil; and the planting of catch crops, as beans, peanuts, or similar plants, between the palms in young groves or in older groves where the palms are spaced so as to permit the entrance of sufficient light, will doubtless prove profitable in all sections. Animal manures, coconut husks, or any vegetable matter available should be spread over the grove and worked into the soil.

MANGOES.

During the last fruiting season seedling trees of several varieties of East Indian mangoes, including Cambodiana, Amini, Sandersha, Bulbulchasm, and Totafari, bore fruit, this being the second crop for the Sandersha seedlings but the first for all the others. Among these

varieties, none except the Cambodiana bore fruit which resembled the parent variety at all closely either in external character, in flavor, or in color of flesh, and all except the Cambodiana had a high content of long, tough fiber, while the parent fruits were practically free from fiber. Trees from seeds of the variety known as Señora, sent from Cuba a few years ago, bore fruit this year of very inferior quality, although the parent fruit is considered as among the best flavored of the common Cuban types. The Señora trees have made a poor growth but have borne heavily. The seedling trees of the variety Cambodiana, grown from seed produced by grafted trees at the station, have made a very uniform and satisfactory growth, a large majority of them fruiting this year. The fruits from all except one tree were uniform in shape, quality, and flavor and were almost identical with the fruit of the parent trees.

The fruit of the one seedling which differs from the others has some of the qualities of the parent variety, but it resembles more closely the common Porto Rican type known as Blanco and appears to be a cross between the two kinds, showing none of the inferior quality and the deviation from the parent type and from the native shown by seedlings of the other varieties. This fruit is of medium size and has a rounded shoulder, smooth skin, and light yellow, juicy flesh of a melting consistency and a very rich, pleasant flavor, with a large, plump seed tapering to a rather pointed apex. In these points it is almost identical with the Cambodiana. It resembles the native types in that the apex of the fruit is full and rounded, the skin is a deeper reddish-yellow than the Cambodiana, the flesh has a slight turpentine flavor which is not sufficiently strong to be unpleasant, and the seed is thickly set with fiber which, however, is too short to be objectionable. This fruit is considered by some Porto Ricans to be superior in flavor to many of the imported mangoes, and it may prove to be of sufficiently high quality to warrant its dissemination through the island.

The fruiting seedlings indicate that for fruit production none of the varieties tested, except possibly the Cambodiana, is adapted to propagation by seed.

A survey made during the fruiting season this year showed that along the north side of the island and through the higher interior, where there is considerable rain during the blossoming season, the mango crop was small, as is usually the case in these sections. Through the western and southwestern sections, where the winter drought continues well into the spring, there was usually a good crop of fruit. This again points out the necessity of selecting a suitable location for planting if good crops of mangoes are to be secured.

CITRUS FRUITS.

During recent inspections through the citrus sections it was observed that the effect of the lack of fertilizer was already apparent on the trees of a few groves, and reduced crops of fruit will doubtless result unless balanced fertilizers are provided. All wood ashes which have been protected from moisture, as well as all tobacco stems, should be carefully saved for use as potash fertilizers. With these, aside from the applications of chemical fertilizers, which contain 2 or 3 per cent of potash, the grove can doubtless be maintained for a considerable time without marked deterioration. Planters who until recently made heavy applications of potash have been well repaid, as the potash remaining in the soil has nourished the trees so that for the most part they have continued to bear well. Fruit growers will make a great mistake if they are led to believe that the application of potash is not essential to productiveness or that heavy crops of fruit will not soon reduce the potash content of the soil to below the needs of the trees. That a fertilizer rich in potash is needed by citrus trees through the sections of Porto Rico where this fruit is chiefly grown has been well established by experiments.

MISCELLANEOUS INTRODUCTIONS.

Among the large number of introduced plants being tested at the station the following, not previously mentioned, have shown sufficient promise during the past year to be worthy of special note:

Crotalaria saltiana.—Plate II, figure 1, shows a small plat of one-year-old plants of this species growing on a low, heavy soil which, while fairly fertile, is water soaked during the summer months and becomes very hard and dry through at least a few inches from the surface during the dry winter and spring. This photograph, taken April, 1917, near the end of the dry season, shows the heavy vegetation and large seed crop produced, proving the ability of this plant to succeed during both dry and wet seasons. It has been tested in other soil types with good results, has resisted unfavorable weather conditions better than any other of the large number of legumes tested here for temporary crops, and will no doubt prove especially valuable for reclaiming barren hillsides or badly worn or washed soil and for furnishing temporary wind protection for other crops. The plants are very prolific, with a ripening season for the seed extending over a long period.

Tabebuia spectabilis.—Small specimens sent to the station about 8 years ago have made a steady though slow growth and are now slender trees 6 inches in trunk diameter and 30 feet tall, with a comparatively broad spread of branches. While the growth has been too slow to warrant planting for production of the valuable lumber,

which is said to be very hard and durable, this species is of exceptional value as a flowering ornamental. The flowers, growing in large bunches often 6 or 8 inches in diameter at the end of each branch, are of a rich yellow color, and as they often appear after the leaves have fallen, the tree presents a very striking appearance and is probably not excelled in beauty and attractiveness by any other tree in the island. At Mayaguez the blossoms appear in April and remain open a few days.

Corypha sp.—One of these palms planted at the station about 11 years ago made a slow growth for some time, but has been developing rapidly for the past 3 or 4 years. The tips of the leaves reach 36 feet in height and have a spread of 50 feet. The leaf petioles, the margins of which are thickly set with long, sharp spines, are 22 feet long and the leaf is 14 feet in its broadest diameter. The ruggedness and grace of this palm give it a peculiar attractiveness and make it exceedingly valuable for landscape gardening. (Pl. III, fig. 1.)

Plants of the East India sugar palm (*Saguerus saccharifer*) which were planted about the same time as the *Corypha* sp. have proved suitable for ornamental planting in Porto Rico, especially for avenues where they are protected to some extent from the wind. Seed which are now more than two years from the blossom will soon be sufficiently mature for planting and the young palms will be distributed through the island.

REPORT OF THE ASSISTANT HORTICULTURIST.

By T. B. McClelland.

COFFEE.

Within the past year two publications embodying the results of work with coffee have been issued as bulletins of the station. The first[1] dealt with the unsuitability of the upper slopes of many hills now planted to coffee in contrast with the suitability of the lower slopes of the same hills. The second[2] showed the large increase in early yield and development of the coffee tree to be had as a result of removing the seedling from the nursery with its roots in a large clod of earth rather than transplanting with the root system free of earth.

In the coffee plantations at the higher altitudes where climatic conditions are much more favorable for the growth of coffee than nearer the coast, a very serious leaf disease, *Stilbella flavida*, has done extensive damage in many places, so debilitating the tree through long continued defoliation that the crop is greatly reduced and the plantation made unprofitable. On one such plantation,

[1] Porto Rico Sta. Bul. 21 (1917).
[2] Porto Rico Sta. Bul. 22 (1917).

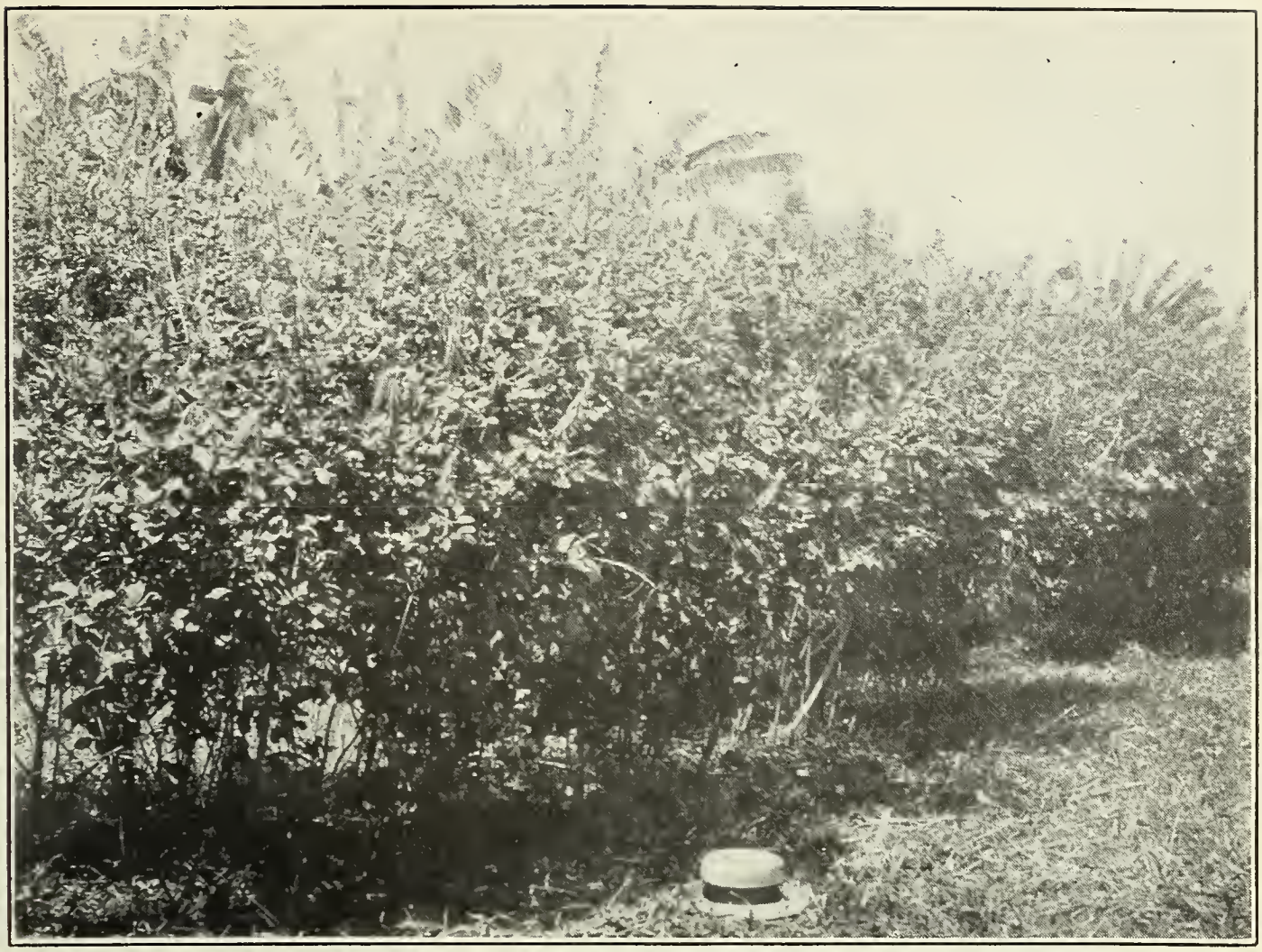

FIG. 1.—CROTALARIA SALTIANA, A GREEN-MANURING CROP.

FIG. 2.—FERTILIZER EXPERIMENTS WITH COFFEE. COMPLETE FERTILIZER AND MANURE ON LEFT, CHECK ON RIGHT.

FIG. 1.—CORYPHA SP., AN INTRODUCED PALM.

FIG. 2.—RED CRILLO CACAO TREE 5 YEARS FROM SEED.

in an almost abandoned state, this department, in cooperation with other departments of the station, has begun an experiment in restoring the coffee to a productive and profitable condition. In the plat selected, of about 1½ acres in extent, the coffee trees were cut at 6 to 12 inches above the ground and their foliage burnt or removed. As numerous weeds are also host plants for this fungus, the ground was cleaned of weed growth, and clean cultivation will be practiced as far as possible. Bananas were planted around the edge of the plat to aid in intercepting the passage of fungus spores from without. At a little more than 6 months after cutting the coffee, the plat appeared to be in excellent condition with new growth 1 to 3 feet in height from the old coffee stumps. No sign of Stilbella was seen, though more than 500 trees were examined.

Different species of introduced coffee have been set in patches of *Coffea arabica* affected with Stilbella in an attempt to find a resistant species.

In continuance of the work with Murta coffee mentioned in the last year's report, 700 seeds were planted from blossoms which had been protected from foreign pollen. Of these, 272 failed to germinate or died before they could be classified. Of the remainder 56.1 per cent were classified as Murta type, 25.7 per cent as the dwarf rosette type, and 18.2 per cent as the ordinary Arabian type. These proportions indicate inheritance of the Murta form along Mendelian lines.

The very short internodes of Murta coffee allow the production of a large number of cherries on a short length of branch. The grains are similar in size and appearance to the typical Arabian coffee, but the tree is slightly later in coming into bearing. The trees are small and the yield per tree through the sixth year has not been large. Indications are that to make this variety profitable two or three times as many trees should be set per acre as of the typical Arabian coffee.

In a fertilizer experiment with 40 plats of 3 young coffee trees each, the first crop at three years from seed showed a large increase in yield from the plats which had received nitrogen, when the results were grouped according to whether the trees had or had not received nitrogen either singly or in combination, the 20 plats not receiving it constituting the check. Of the 12 plats which gave the highest production nitrogen had been used in the fertilizer applied to 10 of them.

In a test with older trees, in which applications of a complete chemical fertilizer and stable manure have been made twice annually for a number of years, the fertilized plat produced this past season 73.4 per cent more than the check. (Pl. II, fig. 2.) The preceding season their yields were nearly uniform, however, the mean of the yields for the two years giving about the usual proportional increase for fertilizer in this planting.

In a lime and nitrogen test with coffee trees grown for two years in 5-gallon cans, the 18 plants grown in the limed soil differed from the 3 check plants in average weight by only a very small fraction of 1 per cent. These had received lime in a series of amounts ranging in rate from ½ ton to 16 tons per acre, the rate being doubled for each group of three trees. From the lightest application the weight of trees averaged 2.4 per cent greater than the check, from the heaviest application 0.2 per cent greater. A few cherries were produced, the average yield from the limed trees being identical with the check. In the division which had received nitrogen there had been made at intervals of six months three applications of 8 grams each per tree of ammonium sulphate to one group and to the others sodium nitrate ranging in amount from 4 to 16 grams per tree per application. The weight of the trees fertilized with ammonium sulphate averaged 22.1 per cent greater than the check; those which had received sodium nitrate averaged 22.9 per cent greater than the check. The trees which had received 4, 8, and 10 grams of sodium nitrate fell below, while those which had received 12 and 16 grams of sodium nitrate surpassed, those which had received 8 grams of ammonium sulphate, 16 grams of sodium nitrate producing an increased weight of 50.3 per cent over the check. The production of cherries averaged 87 per cent greater for the fertilized trees than for the check.

Distribution of seed of promising coffee varieties was continued as in former years.

CACAO.

The work with *Vanilla planifolia* is requiring an increasing to the product of individual trees. (Pl. III, fig. 2.) From the older orchard set in 1903, the yield for the calendar year 1916 exceeded that of any preceding year, though more than one-fifth of the trees produced nothing. (Pl. IV, fig. 1.) The others averaged 20.7 pods per tree. More than half of the crop matured in April, May, and June. Rats have become exceedingly destructive in this planting, at times destroying as much as 75 per cent of the crop and even eating out pods before they have begun to change color. The low form to which the tree should be kept for picking, the fruiting habit of the tree, and the inclination of the land all combine to make it impracticable to keep rats out. For many weeks poisoned pods were placed in the planting twice weekly, but this proved entirely ineffectual in controlling the rats, as pods were continually ripening on the trees and furnishing a constant and abundant supply of fresh food.

VANILLA.

The work with *Vanilla planifolia* is requiring an increasing amount of time and attention. The personal factor in the handling

of vines and crop plays so large a part that it is a very interesting field for investigation.

In a planting test with 48 tip cuttings of 10 nodes each half were left to wilt in a fairly well-shaded place for an interval of 12 days between cutting and planting, the others being set immediately. Half were planted in a mixture of equal parts clay and river sand and half in leaf mold. Two months after the first were planted half the vines were removed, the others being left 12 days longer. Root growth was measured on removal. These measurements showed the root development to have been 85 per cent greater in leaf mold than in soil, while the new vine growth was also considerably greater. Cuttings which had been wilted for 12 days before planting in root development at two months after cutting fell far behind those which had been planted immediately, but when the cuttings which had been wilted 12 days prior to planting were measured 12 days later than those cut simultaneously but set immediately, it was seen that the root development of vines planted for an equal period was greater for the wilted cuttings. As growth under both treatments was vigorous and highly satisfactory, the planter's convenience should determine whether vanilla cuttings are to be set immediately or left for some days before planting.

Vine growth was marked to determine what maturity was necessary for flowering. Blossoms opened in the spring on vine growth of as late as the preceding midautumn. This shows the importance for the following crop of keeping the vine in vigorous growth through the cropping season and not allowing the full strength to go into the crop being produced.

A period of approximately two months was observed to elapse between the pushing out of the inflorescence bud and the opening of the first blossom. After blossoming the pods attained full length in six to eight weeks, though seven to nine months were required for maturing.

Vanilla blossoms open only once and that in the morning, beginning to close in the early afternoon. Fertilization ensued from pollinations made at various hours throughout the day from before daybreak until after nightfall. Fruit set from more than 90 per cent of the hand-pollinated blossoms in a recorded series and from $1\frac{1}{2}$ per cent of a series not hand-pollinated. No reason was found for the failure of some pollinations to cause fertilization. Working steadily, the writer pollinated in one hour 237 blossoms. This rate did not afford time for the proper selection of blossoms but demonstrated that hand-pollination need not be costly on account of the time requisite for the operation itself.

In curing small quantities, blistering was found to result from sweating the pods between scalding and drying, sometimes 20 to 50

per cent of the pods developing watery blisters. The omission of this sweating reduced the proportion of blistered pods to less than 2 per cent, but an extract expert reported the quality of the unsweated pods as inferior to that of the sweated pods. As the quantities available were too small to retain heat in sweating, the result secured at the station refers only to curing small quantities.

The yield from a small planting of 4-year-old vines averaged slightly more than half a pound of cured beans per vine. Samples were sent to dealers and extract manufacturers and were very favorably reported, indicating a ready market for such vanilla at from $3 to $4 a pound.

REPORT OF THE PLANT PATHOLOGIST.

By H. E. Thomas.

The work of this department during the year was principally with vegetable, vanilla, and citrus diseases. Some time was given to minor diseases of other crops.

VEGETABLE DISEASES.

A wilt disease of beans caused by an undetermined Phycomycete was abundant during the past rainy season. The fungus spreads from the soil to the adjacent leaves, stems, and pods as a vigorous, fluffy white growth which often kills the entire plant in an incredibly short time. Considerable increase in this disease was noted in poorly drained situations. Of 19 varieties tested during a single season, only two, Black Venezuelan and White Marrow, showed any marked resistance to the parasite, the Black Venezuelan variety seeming quite highly resistant.

A rust of Lima beans apparently not previously reported was abundant in the station gardens from April to June, 1917, on Burpee's Bush Lima. It has also been observed near Adjuntas on a type of Lima bean locally called Habas Mayorca. The causative fungus was identified by J. C. Arthur as *Uredo concors*. Considerable damage may be caused by this fungus in the direct destruction of leaf surface and in providing points of infection for weaker parasites, particularly *Isariopsis griseola*.

Powdery mildew (*Erysiphe polygoni?*) was very abundant during the winter months on kidney beans and some minor vegetable crops. Dusting with equal parts of lime and flowers of sulphur easily controlled this fungus.

Cabbage plants at Lares were affected by a virulent form of a disease indistinguishable from the ordinary black rot. The causative organism in culture is similar to *Pseudomonas campestris*. While the

black rot has not been definitely reported from Porto Rico, there seems little doubt that the disease found here is identical with that known in continental America.

Tomatoes at Mayaguez were badly affected by downy mildew (*Phytophthora infestans*) during the cool months of the year, while those planted in the same garden as warm weather approached were practically free from this disease. The leaf mold caused by *Cladosporium fulvum* was severe on tomatoes planted after the rainy season began. Four applications of Bordeaux mixture from April to June checked the disease considerably but did not satisfactorily control it. Plants dusted at the time of the above applications with a mixture of equal parts lime and flowers of sulphur showed as much disease as the controls. A single instance of bacterial wilt has come to notice from Bayamón, the causative organism of which in culture closely resembles the description of *Bacillus solanacearum*.

Other vegetable diseases of less economic importance noted during the year are: Leaf spot of beet (*Cercospora beticola*), downy mildew of melons (*Plasmopara cubensis*), leaf spot of okra (*Cercospora hibisci*), leaf spot of peanut (*Cercospora personata*), downy mildew of potato (*Phytophthora infestans*), and bean leaf spots (*Cercospora cruenta* and *Isariopsis griseola*).

VANILLA DISEASES.

Considerable spotting of vanilla leaves has been found on older plants in moist situations. The common leaf spotting alga (*Mycoidea parasitica*) seems to be the principal organism involved. Young and vigorous plants are not seriously affected by this disease. *Glœosporium rufomaculans* has appeared occasionally on vanilla, causing defoliation and sometimes death of the entire plant. Pruning off the affected part did not prove beneficial after the disease had made any considerable progress. In such case, it is better to replace the plants by vigorous cuttings. By removing diseased material and stimulating the vigor of the plant, this trouble has been reduced to a minimum.

Vanilla plants at the station are affected by a disease of the roots which does not seem to have been described. The underground roots and the aerial roots from 1 to 2 feet aboveground are destroyed and fruiting of affected plants is greatly reduced or is entirely prevented. A species of Fusarium has been repeatedly isolated from the margin of diseased tissue. Infection and control experiments are under way.

CITRUS DISEASES.

The withertip fungus (*Colletotrichum glœosporioides*) has been quite active during the past year, partly because of lowered vitality in the trees from lack of fertilizer. A few cases have been noted

in which the initial injury results from poor drainage, impervious subsoil, or use of sprays. The damage done by this fungus to vigorously growing trees is very slight.

Citrus scab (*Cladosporium citri*) caused considerable losses during the past season, although dry weather in May prevented the usual heavy infection. Experiments in the control of this disease were begun in February, 1917, by L. R. Hesler, of Cornell University, and were carried through the latter part of the season in cooperation with this department. These experiments will be reported upon separately.

The following diseases of cereals have been observed in small amounts: Leaf spot of field corn and sweet corn due to *Helminthosporium inconspicuum*, blast of rice (*Piricularia oryzæ*), wilt of wheat (*Sclerotium rolfsii*).

PROGRESS REPORT ON CITRUS SCAB.

By L. R. Hesler.

Citrus scab continues to prove detrimental to the production of clean grapefruit. Preliminary work started in February, 1917, was carried forward by the writer to April 30 of that year. It was subsequently taken over by the assistant plant pathologist, to whom much credit is due for ably prosecuting the investigation. Most of the writer's time was devoted to a study of the cause and control of the trouble.

Microscopic and cultural studies support the contention that scab is caused by a parasitic fungus, as has been found in Florida.[1] The organism is referred to in literature as *Cladosporium citri*. Observations indicate that several factors are concerned in the amount of scab. Meterological conditions not only affect the fungus but also exert an influence on the growth of the grapefruit, tending to increase its susceptibility. Likewise the use of fertilizers induces rapid succulent growth of the host and hence increases its sensitiveness to scab.

Preliminary spraying and dusting experiments were conducted in two different groves on the island. The following materials were used: Bordeaux mixture; lime-sulphur 1:30 (commercial solution); soluble sulphur, 3 pounds to 100 gallons water; sulphur dust (finely ground flour); and soluble sulphur dust with various diluents as lime, sulphur flour, cornstarch, and talc. The applications, varying in number from two to seven, were made in March, April, May, and June. The question of the number and frequency of applications needs further attention. Several trees were also left untreated as

[1] Fawcett, H. S. Citrus scab. Florida Sta. Bul. 109 (1912), pp. 51–59; Phytopathology, 6 (1916), No. 6, pp. 442–445.

checks. In general, Bordeaux mixture was more efficient in the control of scab, but it also destroyed the scale parasitic fungi. The sulphur fungicides were less effective for scab control but also less injurious to the scale parasites. It is the writer's opinion that several applications of a standard liquid sulphur fungicide, such as lime-sulphur solution, applied for the control of both scab and scale, supplemented by occasional spraying with Bordeaux mixture for scab, will be worth thorough trial in commercial groves. The number of applications will be variable, depending on the rapidity with which new growth is uncovered and on the severity of the case in hand. The scab problem deserves more intensive investigation.

REPORT OF THE ENTOMOLOGIST.

By R. H. Van Zwaluwenburg.

THE CATTLE TICK.

The life history study of the Australian cattle tick has been continued. A complete understanding of the various nonparasitic stages of the tick is necessary to successful starvation of the pest by pasture rotation. The accompanying tables show some results of the work.

The insectary rearings were made in a weather shelter of the standard Weather Bureau type. The outdoor rearings were made in concrete drain tiles set in the earth with a few inches of the tile above the surface of the soil. Weeds and grass were allowed to spring up inside the tile, which was filled with soil to the level of the earth outside. A cylinder of galvanized netting closed at the upper end was set over the tile, affording an eminence for the seed ticks to congregate upon.

The quickest and most certain way to exterminate the tick is, of course, by a wholesale and consistent dipping program. The starvation method is not practicable in case of work cattle subjected to reinfestation along any road they travel nor in cases where only limited pasturage is available. A campaign of tick eradication in Porto Rico will, as in the States, have to depend primarily upon dipping, with starvation as a supplementary measure. Dipping kills all ticks brought on the cattle to the vats, while starvation of ticks prevents the dipped cattle from being reinfested.

A dipping vat has been installed at the station and all cattle on the estate are being dipped regularly every two weeks in a bath containing 0.19 per cent arsenious oxid, the standard low-strength solution. The minimum time for parasitic development of ticks on a heifer is 20 days in October. Dipping every two weeks allows for

any lessening of this minimum during warmer seasons of the year and has the advantage of regularity. Cattle dipped every two weeks are in no way injured; even the milk flow of the dairy cows is not noticeably lessened.

One hundred and thirty engorged ticks were passed through a dip containing 0.16 per cent arsenious oxid. Only 30 (23 per cent) died without laying, showing that such strength is not effective against adult females.

Preoviposition period of female ticks kept in closed tins in weather shelter compared with same period under natural conditions.

Month.	Weather shelter.					Natural conditions.				
	Preoviposition period.			Number of females in series.	Average mean temperature.	Preoviposition period.			Number of females in series.	Average mean temperature.
	Average.	Minimum.	Maximum.			Average.	Minimum.	Maximum.		
1916.	*Hours.*	*Hours.*	*Hours.*		° *F.*	*Hours.*	*Hours.*	*Hours.*		° *F.*
September	85.9	65.0	113.0	20	80	84.4	65.5	95.3	11	80
October	90.5	77.5	117.5	10	80	82.4	72.0	91.0	19	80
November	109.8	79.5	179.5	10	79	95.8	87.3	106.5	18	79
December	111.7	87.5	136.5	10	76	.....	.....	.....	.....	.....
1917.										
January	150.4	122.7	231.7	10	72	.....	.....	.....	.....	.....
February	146.3	118.5	219.0	10	71	.....	.....	.....	.....	.....
March	138.8	119.8	167.8	18	73	.....	.....	.....	.....	.....
April	110.3	75.5	126.0	8	74	.....	.....	.....	.....	.....
May	114.5	95.3	136.3	10	76	.....	.....	.....	.....	.....
June	95.6	74.3	122.0	19	77	.....	.....	.....	.....	.....
July	94.8	77.5	124.2	16	79	.....	.....	.....	.....	.....
August	100.8	81.0	129.5	20	78	.....	.....	.....	.....	.....

Egg-laying period of female ticks kept in closed tins in weather shelter compared with same period under natural conditions.

Month.	Weather shelter.				Natural conditions.			
	Egg-laying period.		Number of females in series.	Average mean temperature.	Egg-laying period.		Number of females in series.	Average mean temperature.
	Average.	Maximum.			Average.	Maximum.		
1916.	*Days.*	*Days.*		° *F.*	*Days.*	*Days.*		° *F.*
September	13.8	19	32	80	12.3	14	12	80
October	13.5	17	10	79	.....	.....	.....	.....
November	17.0	20	10	77	.....	.....	.....	.....
December	14.9	18	10	74	.....	.....	.....	.....
1917.								
January	16.6	20	10	74	.....	.....	.....	.....
February	13.4	16	10	73	.....	.....	.....	.....
March	13.8	24	19	72	.....	.....	.....	.....
May	9.9	14	10	79	.....	.....	.....	.....
June	11.3	15	8	79	.....	.....	.....	.....
July	11.9	17	8	80	.....	.....	.....	.....
August	14.4	18	10	79	.....	.....	.....	.....

Incubation period of tick eggs in weather shelter compared with same period under natural conditions.

Month.	Weather shelter.					Natural conditions.				
	Incubation period.			Number of lots in series.	Average mean temperature.	Incubation period.			Number of lots in series.	Average mean temperature.
	Average.	Minimum.	Maximum.			Average.	Minimum.	Maximum.		
1916.	*Days.*	*Days.*	*Days.*		°*F.*	*Days.*	*Days.*	*Days.*		°*F.*
September	29.7	28	32	32	80	26.7	23.0	30	6	80
October	29.6	27	32	22	79	26.6	25.0	29	8	79
November	31.0	30	33	11	76	30.1	29.0	32	6	76
December	.....	.....	.....	.....	.....	38.3	30.5	44	8	73
1917										
January	39.0	38	40	2	73	34.0	28.0	42	8	73
February	37.9	35	41	9	72	.....	.....	.....	.....	.....
March	34.6	32	36	8	73	.....	.....	.....	.....	.....
April	28.6	27	32	11	76	.....	.....	.....	.....	.....
May	28.4	27	31	7	78	.....	.....	.....	.....	.....
June	28.6	26	31	7	79	.....	.....	.....	.....	.....
July	26.5	25	29	13	79	.....	.....	.....	.....	.....
August	26.4	24	30	12	78	.....	.....	.....	.....	.....

A NEW CORN PEST.

It is a very common thing in Porto Rico for a large percentage of ears in a corn planting to fail to set kernels. This is apparently due principally to the work of the larvæ of an undetermined phorid fly, which was first noted during the past year. While work was under way against the corn ear worm and fall army worm, it became evident that those two pests were in that particular instance of minor importance as compared with the "corn-silk" fly.

The slender white eggs are laid in clusters of 25 or more among the strands of the new silk, several egg clusters often being placed in the tuft of a single ear. The larvæ upon emerging from the egg feed on the silk strands, following them downward. Often practically all of the strands will be destroyed in this manner before the silk has been pollinated, and as a result almost no kernels will set. The work of the larvæ also attracts scavenger beetles such as Carpophilus and no doubt paves the way for fungus infection. In June over 75 per cent of the ears in a field at the station were found either infested with larvæ or with eggs in the silk tuft.

Bagging several ears as soon as eggs were found established the fact that the fly is a primary pest and not a scavenger. A capsid bug was found in some numbers apparently feeding upon the eggs of the fly. Observations upon the corn-silk fly are being continued.

MISCELLANEOUS.

The striking black and white larvæ of the noctuid moth *Noropsis hieroglyphica* feed commonly on the foliage of *Waltheria americana*

and have also been reared upon *Morongia leptoclada*. The larvæ are more or less gregarious and drop to the ground when disturbed. The full grown larva is about 25 millimeters long and about 4 millimeters across the head. The ground color of the body is bluish or greenish white with a black stripe running around the body on each segment. The segments are divided one from another by a narrow black line. The anal plate and head are reddish brown, the collar shiny black. The oval pupa case, about 22 by 10 millimeters, is formed of parchment-like material on the stem of the food plant and is covered by grass and bits of leaves.

A heavy infestation of *Anastrepha fraterculus*, the mango fruit-fly, was observed near Maricao in July in poma rosa fruits (*Eugenia jambos*). This is the first record of this plant as a host of the fly in Porto Rico.

Among the very few insects observed upon vanilla, a promising new crop for the island, was the scale *Conchaspis angræci*, which is not likely to become important.

In June there was a general outbreak in the vicinity of Mayaguez of the noctuid *Melipotis januaris* on guamá (*Inga laurina*). On the morning of June 7, thousands of the larvæ were to be seen suspended from the trees; by noon they had practically all regained the leaves. After four days hardly a larva was to be found, the greater part having entered the ground to pupate.

The experiment with lime and salt as repellents against *Strategus quadrifoveatus*, a rhinoceros beetle attacking the coconut, has so far been negative, for no beetles have appeared in the planting. It seems generally true that a surrounding growth of cane, pigeon pea, or similar crop during the rainy season affords some protection from the beetle.

Experiments to determine the value of cyanamid as a remedy for white grubs in cane soil show that heavy applications of cyanamid alone (up to 2 pounds to the stool) have no effect on even second instar grubs. Mixtures of cyanamid with other chemical fertilizers are being tested.

Serious attacks by the slug, or "lapa" (*Veronicella occidentalis*), have been observed on beans and tobacco. Clearing up the breeding places is recommended, as well as trapping the slugs under boards smeared on the side next the ground with attractive substances such as rancid fats.

The trapping of changas at a light has been continued. To date 58 per cent of the catch has been females.

REPORT OF THE ASSISTANT IN PLANT BREEDING.

By W. P. Snyder.

The writer was appointed a member of the station staff in April, 1917. The work to date has consisted mainly of testing introduced varieties of wheat and oats and of making selections for the improvement of varieties of the more important vegetables. It is planned to try out a number of varieties which have not been previously grown at the station, in order to select the more promising ones as a basis for future breeding.

A record was kept of the yields of 52 varieties of Indian wheats and of two varieties of oats known as Swedish Crown and Swedish victory. Seed had been obtained from the Office of Cereal Investigations, of the Bureau of Plant Industry, U. S. Department of Agriculture, and planted in trial rows on February 16 and 19. These dates were found to be too late for good results, as the harvest for the wheat varieties, from May 13 to June 6, was caught by the heavy rains which began on May 22, and the majority of the crop was ruined. The crop of oats was almost totally destroyed, but a few ripe heads were obtained on July 23. The yield of the wheat varieties varied widely, ranging from nothing to the equivalent of 30.8 bushels of grain and 4,629 pounds of straw to the acre for the variety designated as C. I. No. 4558, which was one of the six varieties to mature before the rains set in. Selections were made of the highest yielding plants of a number of the varieties, and in November a second sowing will be made. This will permit a fair comparison of all varieties, as the harvest will thus come in the dry season.

A number of different varieties of beans were planted in April, and selections were made of the highest yielding plants at the time of the harvest in July. Subsequent selections were made from other plantings on the station grounds, and a second generation is now being grown in the hills near Mayaguez, where the facilities for drainage are such that the heavy rains are not particularly injurious. A small planting was also made on the low ground near the station with the view of developing a strain resistant to a soil Phycomycete which is very injurious in wet weather. At present, a black Venezuelan bean seems to be decidedly the most productive of all varieties tested at the station.

Selections have also been made of okra, Chinese mustard, sweet potatoes, and a white sweet corn from Venezuela. It is planned to make a number of crosses between this Venezuelan corn and several of the best sweet-corn varieties from the States which are not productive in Porto Rico.

REPORT OF THE SPECIALIST IN FARM MANAGEMENT.

By H. C. Henricksen.

The author took up the demonstration work October 4, 1916. On account of the fact that most of the plantings of fruits have been made on the northern side of the island, headquarters were established in the Federal Building at San Juan. Two lines of work were planned, one to include the fruit district from Trujillo Alto to Arecibo, comprising that part of the coastal plain not planted to sugar cane; the other to deal with the lower hill district planted chiefly to food crops by small farmers. Getting in touch with the fruit growers offered no difficulties, as nearly all of them were familiar with the station and its work, and the first three months were devoted entirely to visits of inspection to their plantations.

The fruit industry comprising citrus fruits and pineapples is largely in the hands of individuals and in companies organized in the States. The enterprises are mostly financed in the States and the managers are, as a rule, progressive. There are few who are not willing to cooperate in experimental or demonstration work, and it is not unusual to find men who are conducting more or less elaborate experiments without assistance. On that account, a great deal of information has accumulated which needs to be brought together, sifted, and compiled. An outline of such work was drawn up and a beginning made by reorganizing the Horticultural Society, but the undertaking got no further than the initial stage because of pressure of other work. The work of coordinating data based on local experience should be finished before further experimental work is undertaken, as by use of these data many minor problems which might demand experimental attention will be eliminated and the outstanding problems can be attacked intelligently.

The other line of work mentioned above, that in the lower hill districts where food crops are produced on small patches of ground, was inaugurated during the early part of the year in connection with the emergency work of the Food Commission. This is a work of such great magnitude that one or two men could not attempt to cover the whole field, but fortunately cooperation with the department of education is possible. During the last few years that department has been paving the way for agricultural extension work through the rural schools, the whole staff, from the commissioner of education to the teachers in the rural districts, being intensely interested in agricultural development, especially among the small farmers. Acquaintance with the teaching staff and with the school work was gained during the winter by attending teachers' conferences held in the different school districts and so-called parents' meetings held usually on Sundays in the outlying districts. Mimeographed

FIG. 1.—CACAO PLANTATION.

FIG. 2.—EMERGENCY FOOD PRODUCTION MEETING, SABAÑA GRANDE, P. R.

circulars, lectures, charts, etc., were furnished to a number of teachers for these meetings and some lectures with lantern slides were given. Plans were outlined for continuing the work along these lines, which, by the month of May, were well under way.

At that time, the work as outlined was greatly extended by the appointment of a food commission by the governor, the writer being appointed a member of the subcommittee on agriculture and given entire charge of the agricultural field work undertaken by the commission. This food commission was created by a joint resolution of the legislative assembly and given an appropriation of $1,000,000, out of which a certain amount was set aside by the commission for agricultural field work, an organization being formed which by the end of the fiscal year numbered 44 men, all former or present employees of the department of education familiar with the districts in which they were appointed and with agricultural work, although they were by no means agricultural experts. However, expert knowledge was not required, the small farmer of Porto Rico not having reached the stage where he can utilize such knowledge. He needs to be told the rudimentary facts and to have demonstrated the simpler improved methods.

The agricultural agents went from farm to farm, urging people to plant food crops, telling them what to plant and how to do it in a manner to insure better yields, trying to induce the large landowners to let poor people plant idle land on shares, and urging idle people to go to work and plant. Meetings were held in towns and villages and in the schoolhouses in the most remote mountain districts, committees were appointed and associations were formed in all parts of the island, so that in a few months the interest created was far beyond expectation. (Pl. IV, fig. 2.)

At the beginning of the school year (Sept. 1, 1917), the service was entirely reorganized. Twenty-five men, most of whom were graduates of the Porto Rico Agricultural College or other agricultural schools, were engaged by this department and paid by the food commission. A scheme was perfected for cooperating with the department of education by which the agricultural teachers became partly responsible to the station and all rural teachers became collaborators, while the 25 men paid by the food commission became district agricultural inspectors partly responsible to the district school supervisors. This arrangement is very satisfactory to all concerned and through this cooperation both departments have been enabled to do more efficient work.

Among the lines of regular work now under way, the following are of greatest importance:

The first general crop statistics collected in Porto Rico were finished in August and the data obtained show the acreage of food

crops, the work being continued through weekly reports, and all other crops, as well as live stock, being reported upon twice per year.

Committees are being formed in all districts and it is hoped that before the end of the school year there will be an agricultural committee in practically every barrio in the islands.

The "parents' meetings" of the educational department having largely developed into agricultural meetings, this office is sending out thousands of copies of lectures, circulars, charts, Farmers' Bulletins, and other educational matter for their use.

Certainly the experiment station has been brought to the farmer in Porto Rico, as there is not a district where some improved method or some new crop is not being demonstrated and none where some worn-out clay soils are not being rendered productive by the growth of velvet beans, cowpeas, soy beans, or other legumes.

REPORT OF THE AGRICULTURAL TECHNOLOGIST.

By W. A. Mace.

The personnel for demonstration work in the southern part of the island consists of the writer and two assistants. Much of the work has necessarily been carried on by correspondence, several hundred letters having been received and answered by the division and numerous others referred to members of the scientific staff of the station for action. The writer has visited farms in almost every section or municipality on the south coast of the island and has established cooperative relations with about 50 farmers. Campaigns for a greater production of foodstuffs have been launched. A liberal distribution of seed, plants, and agricultural literature has been made. Members of the station staff have on various occasions accompanied the writer for the purpose of giving advice and assistance along technical lines. Hundreds of farmers have visited the station to inspect the experimental and demonstration work carried on there, and great numbers have visited the cooperative demonstration plats in the various localities.

There were distributed among the farmers 2,000 packages of vegetable seed obtained from the United States Department of Agriculture, about 1,000 packages of seed from various field crops grown at the station, about 1,000 fruit and ornamental plants, and about 3,000 publications such as bulletins and circulars of the department and station.

Members of the division have assisted in the organization of an agricultural club, which is doing good work and bids fair to accomplish a great deal in disseminating valuable information among the farmers of the section where it is located and in furthering the

work by improving social and business conditions among the small farmers. Members of the division have attended about 15 agricultural meetings, taking part in the discussions and using stereoptican views, charts, and photographs.

Members of the division have made it a point, when out on trips, to visit the school and town officials, and in many instances they have been given the opportunity of assisting or advising these officials in connection with the school gardens, tree planting, etc., in the towns. Also the school teacher or mayor of a town has often put the station in touch with farmers having some agricultural problem to solve or with progressive men able to cooperate in the demonstration work.

About two hundred farms have been visited, usually at the request of the planters, for consultation regarding some practice or problem on the farm, in some instances members of the station scientific staff having accompanied the demonstration workers. Some farms carrying on demonstrations have been visited several times so as to permit supervision of the work. A great number of farmers have visited the station, showing great interest in the demonstrations under way and in many cases putting some of the principles into practice.

In view of the unusual conditions now prevailing, great stress has been put on a greater production of foodstuffs. In this work recourse has been had to such measures as visiting the farms, consulting with the farmers, holding conferences in the various localities, writing newspaper articles, and sending out circulars encouraging the farmers to plant more food-producing crops. Flattering results have been obtained from this phase of the work. A great number of the cane planters have made a departure from their regular cropping system and have planted large areas to corn, beans, and root crops.

The organization of a chain of cooperative demonstration plats was begun with the object of demonstrating by concrete examples improved methods. Much attention has been given seed selection, cropping systems, soil conservation, etc., also demonstrations of the value of new crops and methods of handling these in different sections of the island. In much of this work the station serves in an advisory capacity, in many instances furnishing seed for planting to farmers, who do the work on demonstration plats according to instructions. As the operations on these plats are watched very closely by the neighbors of the cooperators, it is apparent that convincing results will have a good influence.

Owing to the wide variation of climatic and soil conditions in the different localities, it is often found that, while certain crops give good results in one section, some other crop will give better results a few miles away. The planting season and the cropping system

also vary with the same crop in different localities. With these facts in mind, the division has made special efforts to encourage a system of more diversified farming by the introduction of new crops, and along this line it made the greatest achievements of the year. The crops used were rice, soy beans, Sudan grass, velvet beans, Napier grass, and new varieties of cowpeas, corn, and beans.

The farmers have been found very much interested in cooperating in this work, and in the case of rice many of them were eager to make extensive plantings. The extension of rice culture offers great opportunities, as climatic and other conditions seem favorable to the growing of this crop and as a ready market for the product is assured by the fact that rice is one of the principal articles of food in Porto Rico. One other point which adds to the attractiveness of rice culture is that there are great areas of land now lying idle which may be reclaimed and profitably planted to rice. All indications are that the rice industry is sure to make great strides as various irrigation projects are developed.

The soy bean also bids fair to become one of the principal crops, because of its food value and its hardiness, which makes it a much surer crop than most beans now planted in Porto Rico. Plantings of the soy bean have been made on the cooperative demonstration plats in various sections and have given good results. As soil inoculation has been carried out rather slowly, better results are expected when this is accomplished satisfactorily.

The several forage crops introduced are gaining a foothold with many farmers. It is hoped that the results from this work will be a greater production of very necessary stock food and the employment of a better cropping system than that generally followed in some localities.

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